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S. Yu. Protsyuk

ABSTRACT

The author indicates, on the basis of historical and current literature, the role played by Ukrainians in advancing aeronautics. The development of rocketry in the Soviet Union is discussed with particular emphasis on the participation of Ukrainian scientists and engineers. The review closes with an analysis of limitations which affect adversily research work in the Ukraine and which represents a by-product to todays political and economical situation there. Apart from security considerations there is an evident reluctance on the side of Soviet authorities to discuss contemporary contributions of the Ukrainian science in space exploration.

One of the previous issues of Visti TUIA [Tovarystva Ukrayins'kykh Inzheneriv v Angliyi] (News of the Society of Ukrainian Engineers in England) (No. 2-3 (87-88), 1965, pp. 61-63) contained the text of an interesting article by R. Borysten-Tkach with notes by the author of these lines on aeronautic engineering in the Ukraine. Limited by time and by space in the journal we were unable to give an accurate picture of this subject. Special studies should be devoted to this topic and such a book may possibly soon appear in the Ukraine. Here we wish to supplement the picture of the state of affairs with several facts which are of substantial importance. /79*

In connection with today's multipassenger aircraft designs (e.g., the Boeing 707, the Ilyushin-62) it is interesting to recall a somewhat forgotten project of our famous designer Kostyantin Oleksiyovych Kalinin. K. O. Kalinin (a graduate of the Kiev Polytechnical Institute) as early as 1931-1932 designed and built the then largest aircraft in the world, the K-7. This was a giant plane which could carry 120 passengers along with a twelve-man crew. The most interesting aspect of the K-7 was that it had seven motors with a capacity of 5220 h.p. The aircraft, the frame of which was the first in the USSR to be welded of tubes of a special chromium-nickel steel that was manufactured by the Dniepropetrovsk Metallurgical Plant imeni Grigoriy Petrovskiy, weighed 44 metric tons. Older residents of Kharkov well remember what an unprecedented sensation at that time were the flights of this aircraft over the city in 1933. Unfortunately, during one of the test flights the aircraft was wrecked, and then the rumor became current in Karkov that this was the work of expressly

*Numbers given in the margin indicate pagination in original foreign text.

dispatched saboteurs.* In 1933-1938 the Special Planning Office headed by Kalinin worked up drafts for giant 500-passenger aircraft projects, but it was not lucky enough to put them into effect because in 1938 Kalinin and his co-workers were accused of "Ukrainian nationalism" and liquidated.

As for the K-7, a few things nevertheless have remained unclear. Thus, according to data of the British engineering service the version of the K-7 which was tested in Kharkov between 11 July and 21 November 1933 was the military version of the plane, and not the civil, as certain Soviet sources now assert (see, e.g., the journal Nauka i suspil'stvo, No. 9, 1965, pp. 38-41). The K-7, it is revealed, was indeed an experimental heavy bomber armed with three 22-mm cannons and six 7.62-mm ShKAS machine guns. The aircraft had six motors (and not seven, as some sources say); they were rotary, 12 cylinders, type M-34 F, each developing 750 h.p. The speed of the plane was 225 km per hour and its range 1000 km. The plan of the civil version of the K-7 mentioned above was worked out by Kalinin's office in 1932-1935. It is desirable to emphasize that the K-7 was an airplane of the flying-wing type: the fuel tanks and passengers' cabins (e.g., a version with 64 separate sleeping compartments was developed) were located in the wing, and in the fuselage suspended from the wing were only the pilot's cabin and the command cabin. The fate of Kalinin's office in 1935-1938 and of the prototypes of the civil version of the K-7 has not been investigated.

The work of the chief designer Oleg Kostyantynovych Antonov, which was /80
crowned among other things by production of the colossal aircraft An-22 (called "Antey" ["Antaeus"]), which in its civilian version carries about 650 passengers and a crew of around 40 (together with stewardesses), is a worthy continuation of Kalinin's efforts. The An-22 was built in a plant in the Ukraine and flew for the first time in Ukrainian skies in February 1965, but already in August 1965 serial production of these aircrafts both for passenger and freight (and military) transports had begun.

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*Most Soviet sources even today mention only the ANT-20 (or the TsAGI-20 known as the "Maksim Gor'kiy") as the first giant airplane in the USSR. This plane was in fact the second after the A-7, for it flew in 1934 (and burned up in a crash). It is curious that research in the archives shows that even such a respectable journal of the time as Aviastroitel' (ONTI Aviyaavtoizdat) for 1933 does not mention the K-7, although the Ukrainian press wrote about it at the time, but in No. 8, pp. 17 we find in an article by N. S. Bobrov an interesting mention of Antonov and a contemporary photo of him. Antonov was at that time the designer of the gliders "UTs-3," "Upar," (Vapor,) and "6 usloviy" (Six conditions).

Antonov was still building gliders in 1939. It was in his glider "Rotfront" ("Red Front") that O. A. Klepikov in July 1939 set the women's world record for distance gliding (749 km), which has not been broken to the present day; see S. I. Karatsub, "Gliders of the Kiev Polytechnical Institute", Narysy z istoriyi tekhniky ta pryrodznavstva, No. 5, Academy of Sciences, UkSSSR, Kiev, 1965, pp. 87-97.

It should be noted here that Antonov is one of the very few Soviet aircraft designers who have been honored with very many articles in Soviet periodicals.* This acknowledgment, it is true, was accorded him when a number of foreign specialists had written extremely effectively about his work. By the way, abroad not only were Antonov's projects praised, but after the success of his An-22 a number of powers threw themselves hastily into projecting for themselves, too, airplanes for a great number of passengers. In the United States, for example, data were announced about designs of the Boeing 747-136 and 747-137 for 295 passengers, the L-500 (Lockheed), and the DC-10 (D-950 and D-952 configuration) for even more passengers; they are all based on the plan of the military transport C-5A. These designs, however, for the time being exist only in approximate drawings and will hardly be realized before the second half of the seventies. Far better chances for realization are those of the projected French aerobus "Gallion" (250 passengers) and the British project HS-136, which are being developed respectively by the firms Sud-Aviation & Marcel Dessault and Hawker-Siddely-Nord Breguet.**

At this point, however, we should like to note that beside the leading lights of Ukrainian aircraft design like K. O. Kalinin and O. K. Antonov numerous enthusiasts and specialists in aeronautical engineering had been working for decades in the Ukraine, and the time has come to rescue them from oblivion or intentional silence. Investigations in that regard have somewhat improved only very recently, especially when in spring of 1962 a Section on the History of Aviation and Cosmonautics was organized in the Ukrainian Division of the Soviet Historians Union. In 1963-1964 were published M. B. Lyakhovets'kyy's

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*Shevtsova: "Beauty and Machines," Kul'tura i zhittya, 11 July 1965. Henryk Kucharski: " A Meeting with the Designer of the Largest Aircraft in the World," Skrzydlata Polska, 15 July 1965. Yu. Kirzhner, V. Fedorov, and I. Turchannikov: "Meet the An-2M," Grazhdanskaya aviatsiya, No. 12, pp. 11-14. M. Chugunov and V. Chelyukanov: "The Pathway of a Designer," Grazhdanskaya aviatsiya, No. 3, 1966 (this same article under the changed heading of "The Creator of Flying Ships -- the Sixtieth Anniversary of O. K. Antonov is also contained in the journal Kryl'ya rodiny, No. 2, 1966, pp. 10-11).

More detailed data on the civilian version of the An-22 and the present stage of its execution are found in the Italian periodical Alata-Internazionale, April 1966, 10. This number of the Italian periodical is in general extremely interesting to us, for we find in it a description of Antonov's other projects, of Ivchenko's motors, and, most important, a description of a visit to the famous aircraft plants in Kiev and Zaporozh'ye.

**From these projects for multipassenger "aerobuses" (more than 250 passengers; the An-22 would have room for 724 individuals) must be differentiated plans for multipassenger supersonic aircraft such as the French-British "Concord" or the Soviet Tu-144 (Tupolev-Kuznetsov), which are presently under construction (each for about 125 passengers). The Americans also have plans for such planes, e.g., the Lockheed L-2000-7 (Mach 2.7) and the Boeing-733, which are intended to be put into operation in 1980-1988.

essays on Grygoriy Semenovych Tereverko (1888-1912), an aircraft designer of the so-called pre-war Kiev school, and an essay by V. I. Denisenko on Grygoriy Gerasymovych Chechet (1870-1922) of the same school and designer of the ChUR-1 which was the center of attention at the Second International Aeronautical Exposition in Moscow in 1912. Up until the present day the investigations have dealt chiefly with Ukrainian aircraft designers whose activity took place in the years before the First World War. Here too, however, there is the limitation that in the meantime no mention is made of the aeronautical enthusiasts from the circles of the nobility, great industrialists, and the higher Czarist officials. Meanwhile from the minutes of the sessions of the Imperial All-Russian Aero-Club in St. Petersburg as early as 1909, for example, it is known that applications for active membership in the Aero-Club were entertained from such Ukrainians as Mykyta Mykytovych Syrenko, Volodymyr Volodymyrovych Sologub, N. Ya. Yatsuk, Oleksandr Artemovych Polishchyk (the famous architect), Vasyl' Mykhaylovych Narbut, Vasyl' Mykolayevych Protsenko, and Pavlo Petrovych Skoropads'kyy. Even the head of the Club, A. M. Kovan'ko, was a Russianized Ukrainian; speaking of this, it was precisely he who persistently supported such people as Chechet and the "Kiev school" in general. Our countryman A. Yushchenko was the director of the student aircraft-building club at the St. Petersburg Polytechnical Institute in 1909-1910.* /81

In the official list of pilot-aviators for 1911 we find the names of Ukrainians like

Name	Born	Active at	Type of craft
Mykhaylo Zelins'kyy	1866	St. Petersburg	Antoinette
Lev Matsiyvych,	1877	Kiev	Farman
Oleksandr Serdyns'kyy,	1879	Kharkov	Farman
Mykhaylo Komarov,	1879	Kharkov	Antoinette
Andriy Seredyns'kyy,	1879	Kharkov	Bleriot (?)
Andriy Kuz'myna'kyy,	1880	Kharkov	Bleriot
Vasyl' Pshanovs'kyy,	1880	Odessa	Bleriot
Gnat Semenyuk,	1884	Mitava	Bleriot

Of all those mentioned we still know most about Lev Matsiyevych; the others are awaiting their investigators.

Detailed studies in the archives are revealing extremely interesting aspects of the history of Ukrainian aviation. It has been disclosed, for example, that Mikhayle Nikiforovich Yefimov, whom all Russian sources extol as

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*The popularity of flying in the Ukraine even in the years before the First World War is attested, among other things, by the activity of such a publishing company as that of A. S. Suvoryn in Odessa (with stores also in Kharkov and Rostov-on-Don) which already in 1909 was publishing large press runs of books on the field of aviation; the demand was especially great for the book Aeroplan" dlya vsekh" (The Aeroplane for Everyone) (a translation from the French), which gave an accurate review of achievements in aviation up till 1908; the book was translated by the Odessa engineers O. Blinderman and M. Bisk.

the "first Russian aviator" (he won his pilot's certificate in France on 15 July 1910), was linked in every way with the Ukraine. His ancestors, to be sure, were from Byelorussia, but he spent his whole life in the Ukraine, finished the Odessa Railroad Engineering College in 1902, worked on the Southwestern Railroad, and from 1910 was instructor and director of the Sebastopol Aviation School.* The details of Yefymov's tragic death are unclear -- he was shot by Russian White Guards in Odessa, and the fact that notwithstanding his services he found no mercy from the Black Hundred Russians indicate his negative attitude toward Russianism. To the point, Yefimov's wife, Yevgeniya Grygorivna Chernenko was obviously a Ukrainian woman; there is also information that Yefimov worked in close collaboration with revolutionary figures in the Crimea -- Ukrainians like Remzyuk (from the Kacha Aviation School) and Romanets' (from the Black Sea Fleet).

A second famous aviator of the period of the First World War, Yevgraf Mykolayevych Kruten' (born 29 December 1890, a native of Kiev) was undoubtedly a man of Ukrainian stock. He was a graduate of the Kiev Cadet School and of the Kostyantyn Artillery School, served in the Third Kiev Aviation Company, later finished the Gatchina Aviation School, and was the author of the popular pamphlets Povitryaniy biy (Aerial Combat) and Stvorennya Boyevykh letuns'kykh grup (Formation of Military Aviation Groups) (both published in Russian). Kruten' perished in an airplane crash on 7 June 1917.

The list of famous pilots of the period of World War I and the Revolution may be lengthened with further names, e.g., among those awarded decorations in military actions in 1920 we encounter the figure of the eminent aviator Tymofiy Illich Isachenko, and there were many more such Isachenkos in the early twenties. The complement and fate of the Tenth Air Navigation Company (the so-called vozdukhoplavatel'naya) which was stationed in Berdichev and participated in numerous military operations deserves investigation. It would be interesting to find out what Ukrainian officers took part in the First Soviet Army Conference of Aviation Commanders which took place in Mykolayev in 1921, and who among them organized and directed the first aviation squadrons in the USSR. It is known, however, that even during the so-called Great Kiev Maneuvers in 1928 the only bombing squadrons in the USSR were four stationed on White Russian and Ukrainian ethnographic territory (Kiev, Gatchina, Gomel', and Voronezh). /82

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*This school later received the name of the Kacha School (from the little River Kacha near Sebastopol where the school buildings were erected). The Kacha School is considered the most renowned air force academy in the Ukraine and all of the USSR -- it produced nine aviation marshals and 151 aviation generals. The scool existed in the Ukraine from 1918 to 1941, when it was evacuated into the Saratov Oblast, and these years were its most famous and brightest. After the war the school was not returned to the Ukraine; in 1953 new quarters were built for it in Volgograd. To maintain tradition it is also called the Kacha Aviation School in its new location, but, although many Ukrainian officers are studying in it today, it is no longer so closely associated with the Ukraine as during its notable existence near Sevastopol.

In addition to the facts and individuals directly associated with aviation and the operation of aircrafts we have the facts on scientific and technical studies in the Ukraine in the period before World War I which underlie the design and construction of aviation equipment. These facts are still inadequately elucidated, as the history of the development of technical sciences in the Ukraine in the nineteenth century has generally not been studied. Investigations in the archives and sources will be needed to evaluate the contribution to mechanics, hydromechanics, and thermodynamics, and the thermodynamics of such Kharkov scientists, for instance, as V. G. Imshenets'kyy (taught at Kharkov University in 1872-1882) and V. M. Mayzel', or the Kiev scientists M. M. Schiller (taught in the University of Kiev from 1875-1910), Y. Y. Kosonogov, N. A. Bunge, and others. It was from the school of such scientists that later came such luminaries of Ukrainian technical science as M. M. Krylov, K. K. Simins'kyy, M. Ya. Lavrent'yev, O. M. Dynnik, and Yu. D. Sokolov, who in turn trained the present-day generation of scientists in the field of rocket design and astronautics.*

If on the one hand we know the names at least of Ukrainian enthusiasts of aircraft engineering in the prerevolutionary period, and even have rather exact data on some of them (Tereverko, Chechet, Matsiyevych), we have on the other hand extremely inadequate information on the Soviet period and this region is untouched territory for our researchers. If, for example, we take a quick and random look at, say, 1933 we find that the anniversary order to IsIAM (Central Scientific-Research Institute for Aviation Motor Construction imeni P. I. Baranov) awarded the Banner of Labor to our famous inventor Tymofiy Ivanovych Sheyk, who before transferring to TsIAM worked from 1923 to 1933 in the Ukraine. Together with the mention of Sheyk we find fragmentary information on his contemporaries P. Shmat'ko, Shelest, and Gavrysh (Kharkov Aviation Institute), but we lack details. The figure of Andriy Makarovych Metel, who in 1924-1932 worked in the aviation industry of the Ukraine and in 1933-1936 was the head of the production department of the Main Administration of the Aviation Industry, is drawn more distinctly. An extremely interesting figure in this period was Borys Ivanovych Cheranovs'kyy, famous even then as the designer of the so-called tailless airplanes of the "Parabola" and "Trykutnyk" ("Triangle") type (the same as the BYCh-8). Cheranovs'kyy, a native of Vinnytsa, had plans at that period which were highly valued by the noted German scientist Lippisch, and it must be said that many of the most modern airplanes

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*The present President of the Academy of Science, USSR, for example, is a student of Lavrent'yev's; together they published in 1935 the now classical work on the vibrating wing theory, see Tekhnicheskiye zametki TsAGI (Engineering Notes of the Central Aerohydrodynamic Institute imeni N. Ye. Zhukovskiy), No. 45, 1935. Oleksandr Mykhaylovych Pen'kov, Corresponding Member of the Academy of Sciences, Ukrainian SSSR, and professor in the Kiev Institute of Engineers is a Dynnik student. Very many such examples of transmission of knowledge and experience to the younger generation may be cited.

of these sixties of ours are of just this type of "flying wing" plane,* and therefore the priority in studying them belongs to Cheranovs'kyy, who, by the way, later became collaborator in TsGIRD (Central Jet Propulsion Study Group in the Central Council of the Society for the Promotion of Defense and Aero-Chemical Development [about this group see the second part of this article]), where Pavlo Fedorovych Fedosiyenko (simultaneously an engineer in Dirizhablestroy [Dirigible Development]) also worked, as well as Oleksa Petrovych Pavlenko (who together with Mykola Ivanovych Zvonarev worked on rocket weapons for airplanes), the designers M. S. Kysenko, O. Musiyenko, N. I. Yefremov. /83

While the talk is already of the early thirties it is undoubtedly of interest to mention the episode of the two well-known aircraft designers of Ukrainian birth -- D. P. Grygorovych and A. V. Nadashkevych. They both worked in the confidential aircraft plant No. 39; sometime in 1928-1929 they were accused of sabotage and sent to prison, and only the complete standstill of production in the factory mentioned forced the authorities to free them from prison. Their case was examined at a meeting of the very highest authority in the USSR, the Presidium of the Central Executive Committee, and was decided by a special decree of this same Presidium. In 1932 Nadashkevych and Grygorovych even got a government prize (see Front nauky i tekhnyky [The Science and Engineering Front], No. 9, 1932, pp. 50), but in the period of the Yezhov purges they finally disappeared anyway.

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The field which today most captures the minds of researchers is rocket design and plans to conquer space. Because of the secrecy surrounding this field in the USSR (as well as in other countries) almost nothing is known about rocket and spaceship designers. This situation favors the dissemination of the most outlandish conjectures and "hypotheses" which sometimes victimize even reputable scientists; on 7 November 1965, for example, the New York Times printed a report from its Moscow correspondent, T. Shabad, who on the basis of a certain article in Komsomol'skaya Pravda (Young Communists League Truth) attempted with a single stroke of the pen to reveal the mystery of the "pseudonym" of Prof. G. V. Petrovych, the author of detailed descriptions of Soviet

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*Plans for "flying wing" planes were revived during the war years when Alexander Lippisch worked on them in Germany. After the war the Americans took Lippisch to the United States where he worked as advisor to the Air Material Command, Wright-Patterson Air Force Base (1946), Naval Air Material Center, Philadelphia (1947-1950), and later at the Collins Radio Co., Cedar Rapids, Iowa. In 1945-1950 the Northrop Corporation, taking advantage of the experience of German designers, built the prototype planes XB-35, YB-49, and YRB-49A which tie in with the traditions of aircraft of type D-ENFLDFS-39, DFS-194, and DFS 228-V-I, which were constructed by the Deutsche Forschungsanstalt für Segelflug, Darmstadt (German Research Institute for Sailing Flight, Darmstadt).

After moving to the United States Dr. Lippisch worked to perfect his DM-4 design, from which the well-known American planes (Continued on following page)

cosmonautical plans in USSR periodicals. Shabad put forward the surmise that Prof. Petrovych was in all probability the Academician Valentyn P. Glushko who with the late Sergiy P. Korol'ov was said to be the director of the astronautic program in the USSR. Such guesses are built on downright ignorance of the work of Soviet scientists. We do not intend to correct Shabad, but he should be familiar with the fact that Prof. Petrovych is not only the author of articles in central Soviet periodicals, but has now for many years been the author of serious works in the representative journal of Soviet science, i.e., Vestnik Akademii naukSSSR (Bulletin of the Academy of Sciences, USSR). Shabad should thus know of Petrovych's essay in Vestnik No. 9 of September 1965, as well as in Nos. 1 and 11 of 1960, Nos. 3 and 5 of 1961, and so on. The case of Academicians Glushko and Korolev also interests us because of its involvement with the Ukraine. Sergiy Korol'ov was born into a teacher's family in Zhitomir; Valentyn Glushko is also a Ukrainian scientist who worked for a long time in Odessa. Numerous conjectures of foreign journalists about some mysterious director of the Soviet astronautics program -- a "jovial Ukrainian" -- may refer at the same time to Glushko and Korol'ov, and perhaps also to Academician G. I. Petrov or someone else. Western sources know ridiculously little about the scientific activity of the scientists metioned, although if they were a bit stronger they could learn that Glushko, for example, is the author and co-editor of several well-known manuals on thermodynamics, in particular, combustion thermodynamics,* while the range of interests of Academician Georgiy Ivanovych Petrov may also be found from indications in the scientific bibliography of the Soviet Union. It is highly unfortunate that western, above all, American, biographical collections use the principle of the more famous the scientist, the fewer the data on him. English researchers are completely correct in their criticism of this approach and, properly speaking, they deride it.** (See footnote on next page).

XF-92 and F-102 later issued. It should, however, by no means be forgotten that all "Delta"-type planes really came from the prototypes of "flying wing" planes, including the famous German Me-163 which imitates many new American designs. In the second half of the fifties Dr. Lippisch suddenly returned to Europe; from that time the Americans have passed over his outstanding activity in the United States in silence.

*One of the last volumes prepared under V. P. Glushko's direction is the encyclopaedic collection Termicheskiye konstanty veshchestv (Thermal Constants of Materials) (ten editions 1965-1966).

It is interesting to note here that one of the best-known directors of the Soviet astronautics program Mykhayle Vasylevych Khrunikov (1901-1961) was a native of the Ukraine (the Donets Basin); in the twenties he worked in the Artem Plant in Voroshilovgrad; in 1929-1932 he studied in the All-Ukrainian Industrial Academy, but already in 1938 he was the Deputy People's Commissar for Military Production of the USSR and was named People's Commissar in 1946; from the fifties he was director of rocketry in the USSR; he was among the most frequently decorated figures (two so-called Stalin Prizes, seven Orders of Lenin, etc.).

The question of the leadership of the Soviet program for conquering space is too complex a question to be resolved by "deciphering" the data of literature published in the USSR. The collective of responsible directors of this program unites a great number of noted scholars in various scientific fields; besides the previously mentioned specialists we may reckon here in addition, for example, Academician S. A. Khrystiyanovych; M. K. Yangel', Corresponding Member of the Academy of Sciences, Ukrainian SSR; Academicians M. Semenov and A. Blagonoravov; A. Makarevs'kyy and A. A. Pistel'kors, and Prof. G. Rozenberg, Corresponding Members of the Academy of Sciences, USSR; nor must it be forgotten here that the present President of the Academy of Sciences, USSR, Mstyslav B. Keldysh was at one time closely connected with the Central Aerohydrodynamic Institute (TsAGI) and is likewise an outstanding expert in aerodynamics and aeronautics. To this collective we would also have to add further high air force officers,* as well as physicians and biologists, and only then would the picture in some measure approach reality. The "revelatory" press-releases which are often encountered in the American press are essentially in the class of divinations of the worst sort.

We are really interested here first of all in the paths of development of astronautics in the Ukraine and the part played by Ukrainian engineers or scientists in this field in the USSR. In the last few years reports have appeared on the pioneers in rocketry in the USSR. They all seem coordinated and stimulated by some center of technical information in this field and they speak of things about which it is just now permitted to be spoken. Information, for example, about GIRD (Jet Propulsion Study Group, see text below) has been reconstructed with distinct artificiality***; in it is perceptible

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**See "Soviet Space Chief Named Posthumously," New Scientist, 20 January 1966, pp. 129. Note here the book edited by Jan Turkevich (Princeton) entitled Soviet Men of Science (1963). Several other biographical dictionaries of noted /84
people in the USSR are even worse as, for example, Biographic Directory of the SSR compiled by the Munich Institute of Soviet Studies and published in 1958 (Scarecrow Press, New York), and later expanded and published in German and in English under the title Who is Who in the USSR? (1962, 1966) in general gives no names of scientists in the field of astronautics and rocket design. The workers at the Munich Institute have taken the easiest path and given information chiefly about men and women in the arts, writers, party workers and again famous doctors; the data on scientists and engineers are scandalously incomplete or entirely lacking.

*Only by way of illustration do we here mention several Ukrainians like Lieut.-Gen. Ye. M. Gorbatyuk, Maj.-Gen. L. Goreglyad, Lieut.-Gen. G. G. Vlasenko, Lieut.-Gen. V. P. Drogomyrets'kyy, Col.-Gen. O. O. Myronenko, Lieut.-Gen. F. I. Shynkarenko, and the following professors at the Military Aero-Engineers Academy: B. Goroshchenko, A. Zhyvot'ko, V. Khomenko, M. Myshuk, K. Tymchenko, and others. There is not need to speak of the generally known marshals.

***It is interesting that most Soviet sources speak of GIRD and its members ("GIRD-ites") as active in the 1931-1932 (Continued on the following page)

the hand either of the censor or of the "coordinator"; no matter what publications we pick up we find everywhere the same fixed patterns and the same retouching.

In the quadrumvirate of principal pioneers of rocketry in the USSR there were certainly two Ukrainians -- Mykola Ivanovych Kybal'chych and Yuriy Vasyl'ovych Kondratyuk. By the way, of the four founders of rocket design K. E. Tsiolkovskiy alone was perhaps strictly Russian.* The fourth experimenter, Fridrich Arturovich Tsander was a Latvian born in Riga on 23 July 1887.

The figure of M. I. Kybal'chych is interesting, but in our opinion controversial. The presently well-known, but still "mysterious" Professor Petrovych writes expressively of him -- "the renowned son of the Ukrainian people.** Kybal'chych (1853-1881) was a member of "Narodnaya Volya" ("People's Freedom") and took part in the attentat on Czar Alexander II. For this he was condemned to death and executed. He worked out his "rocket" design in the death-house sometime around 23 March 1881. This design of a so-called aerial navigation device remained under seal in the secret archives a full 35 years and was found only in 1971. Kybal'chych's plan as published*** is rather sketchy, but for the 1880's it is of course interesting. Disregarding the fact that Kybal'chych was a Ukrainian, however, we should like to remark that his role in the /85

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period, but the official organ of the Academy of Sciences, USSR, in the pages dedicated to the memory of Academician S. P. Korol'ov clearly says that GIRD was set up only in 1933 (see Vestnik Akademii nauk SSSR [Bulletin of the Academy of Sciences], January 1966, pp. 13).

*But analyzing Tsiolkovskiy's name by patronymic (Konstantin Edvardovich) we could conjecture that his ancestors, too, were of foreign origin; practically Tsiolkovskiy, and even Tsander, considered themselves wholly Russian.

**"At the Sources of Soviet Rocketry," Vestnik Akademii nauk SSSR, No. 10, October 1965.

The first tidings of Kybal'chych and Kondratyuk appeared while still in the "Stalin" period in the early fifties, see L. K. Bayev and I. A. Merkulo, Litaky-rakety (reaktivna aviyatsiya) (Rocket Airplanes [Jet Aircraft]), State Technical Publishing House, Ukrainian SSR, Kiev, 1952, pp. 52.

***Pionery raketnoy tekhniki, Izbrannyye trudy (Kybal'chych, Tsiolkovskiy, Tsander, Kondratyuk) (Pioneers of Rocket Engineering [Kybal'chych, Tsiolkovskiy, Tsander, Kondratyuk]), Nauka (Science) Publishing House, Moscow, 1964, pp. 671.

creation of rockets exaggerated; the role of such inventors as Tsymbalyuk, Pavlenko, Fedosiyenko, Gazhaly, and above all Kondratyuk is far more significant.

Not everything is told about Kondratyuk in the published Soviet sources. Born in 1900 in Lutsk in Volhynia he moved to Poltava during World War I and finished high school (gymnasium) there. As involved in Ukrainian separatist aspirations he could not be admitted to university studies and worked by turns as a fireman, locomotive engineer's assistant, machinist, and technician. The years 1924 - 1930 are the least illuminated in Kondratyuk's life story. Perhaps before the repressions he had made his way as far as Siberia, where in Novosibirsk in 1929 his work Zavoevaniye mezhplanetnykh prostranstv (The Conquest of Interplanetary Space) was published at his own expense. This was a small booklet (72 pages), but so weighty that the name of Yuriy Kondratyuk was immediately numbered alongside the names of such famous pioneers in rocketry as the German Hermann Oberth, the Frenchman Robert Esno-Peltier, and the American Robert Goddard.* It is interesting to note, however, that in his work Kondratyuk properly merely expanded and refined his earlier plans, which he had worked out as about a 20-year-old youth in the Ukraine. Kondratyuk's work met with favorable appraisal in Moscow with rocketry enthusiasts, and at their instigation Kondratyuk after all managed to get to Moscow for conversations with the "GIRD-ites." Finally the affair came to a stop in the People's Commissariat for Heavy Industry, where the conclusion was reached that Kondratyuk was "safe" in the development not of military, but of civil technology and therefore, only his project for an aeolian (wind-operated) electric power station. He was even permitted to return to the Ukraine, where he developed a project for an aeolian electric power station for Kharkov, and in the late thirties he built an experimental aeolian electric plant of Mt. Ai-Petro in the Crimea. In 1941 he was among the myriads of Ukrainian specialists who were forcibly evacuated and mobilized into the ill-famed "storm battalions." Kondratyuk, too, perished near Moscow in the winter of 1941 in the ranks of one of these battalions. Only today has it been seen in the USSR what a loss Soviet technology suffered, and too late it is acknowledged, to quote V. P. Vetchinin, for example, that Kondratyuk's plans were the "most complete study of interplanetary travel of all those which have appeared in the Russian and foreign literature till recently.**" It was not fortuitously that M. A. Chynakal, Corresponding Member of the Academy of Sciences, USSR, at an April meeting in the Lugansk House of Technology gave the example of Kondratyuk as one which must not be repeated in the USSR.*** Among other things Kondratyuk was the first in the

* Borys Marianow: "Yuriy Kondratyuk -- Discoverer of Celestial Roads," Astronautyka (Astronautics), No. 1, Warsaw, 1966, pp. 20 - 22.

** L. Kolodnyy: Zemnaya trassa rakety (Terrestrial Rocket Route), Politizdat (Political Publishing House), Moscow, 1965, pp. 69 - 70.

*** "The Young Researcher's Division Command Post," Zhurnal Nauchno-tekhnicheskogo obshchestva SSSR (Journal of the Scientific Technical Society of the USSR), No. 5, 1966, pp. 55.

world to propose certain light metals (lithium, boron, magnesium, aluminum) as solid fuels for propelling rockets, i.e., the metals which underlay, for example American rocket fuels in 1960-1966. In general the whole, unbroken value of the Studies of Kondratyuk or even Kybal'chych* can be understood only today when a number of their designs are finding direct application in world astronautics. It is characteristic that when more and more articles on Yuriy Vasyl'ovych Kondratyuk are now appearing in Russian, Czech, Polish, and German scientific journals,we know in Ukrainian only the work by V. O. Zemlyns'kyy, Astronavt z Luts'ka (The Astronaut from Lutsk), which appeared in print in the Lvov Book and Periodical Publishing House in 1965.

The quadrumvirate of experimenters were entered into the pantheon of "Fatherland" science on definite directives from above, and more detailed investigations show that to this foursome may also be added other names. There is, for example, no doubt of the important role of Georg Erikhovich Lyangemak, the first director of the Gas Dynamics Laboratory in Leningrad, and of M. Lyaytayzen (Permanent Secretary of the Interplanetary Communications Section in the Military Scientific Society of the Air Force Academy) who were shot (as of foreign origin) in 1937. The work of several Russian investigators and rocketry enthusiasts like N. A. Rynin, M. K. Tikhonravov, N. T. Kleymenov, and V. V. Razumov seems to be somewhat underestimated. Deprecated and passed over in silence is the correspondence of these persons and their connections with German and French rocket scientists of that time. There are likewise insufficient data on several other Ukrainian experimenters. We should like here to mention, for example, K. Tysmbalyuk, who came from the western regions of the Ukraine and later lived in Rostov-on-Don. He also belonged to the "GIRD-ite" group and in 1932-1933 built the rocket "Zenith," a diagram of which we give in Figure 1. Space a in the rocket was filled with fuel (a powder mass of combustible components): the jet of combustion gases which exited at high velocity into zone c abruptly expanded and mixed with free external atmosphere d, while pipe b thus began to act as a pulverizer (atomizer). As a result of the powerful rarefication of the air in pipe b there arose rapid suction of substantial new amounts of air from region o (to restore the impaired pressure balance). The exit velocity of combustion gases together with the air drawn in (Vv) becomes greater than the actual rocket speed (Va). Therefore in even a very fast flight of the rocket there will be no air resistance at its front, and the sole retarding factor will be friction on the side walls of the rocket and on the vertical surfaces of its guide fins. In 1934-1937 Tsymbalyuk worked to improve the "Zenith"; there is no information on his

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*P. M. Babayevskiy in his work Fiziologicheskiye metody v kosmonavtike (Physiological Methods in Cosmonautics), Nauka (Science) Publishing House, Moscow, 1965, pp. 15, says that Kybal'chych's"platform principle" was used in the American Orion project; see also F. I. Ordway III, I. P. Gardner, and M. R. Sharpe, Basic Astronautics, New York, 1962.

projects in the post-war period.*

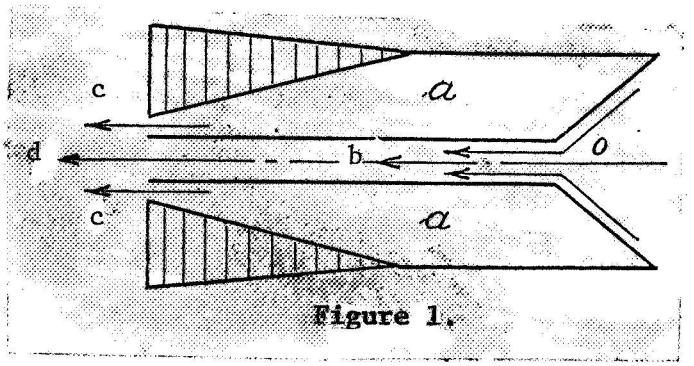

Figure 1.

The Soviet authors who have received permission and commissions to publish findings on the early period of rocketry in the USSR often give conflicting data, frequently exaggerating certain facts while keeping silent on others, and allow themselves to falsify. For example, an organization about which much is now being written (and which we have also already mentioned above) is GIRD, or, properly speaking, TsGIRD (exactly entitled, Tsentral'naya gruppa izucheniya reaktivnogo dvizheniya pri TsS Osoaviakhima SSSR [Central Jet Propulsion Study Group in the Central Council of the Society for the Promotion of Defense and Aero-Chemical Development]). It is not known why most new publications give the address of GIRD as Sadovo-Spasskaya ulitsa No. 19, when the original early sources at the beginning of the thirties speak of Il'inka ulica No. 3 in Moscow. The role of Marshal Tugachevs'kyy [Tukhachevskiy (?)] as protector of GIRD is awkwardly exaggerated. In fact, as new investigations have made apparent, Tugachevs'kyy was "always busy" when GIRD-ites tried to get admittance to him; only through his adjutants did he (perhaps twice) transmit monetary subsidies for GIRD. The sentence remains unexplained which says that Tugachevs'kyy worked "in spite of great difficulties.**" What was the nature of these difficulties and who created them? It is not even clear what Tugachevs'kyy is doing in this connection because in 1932-1933 the enterprises and laboratories of the aviation industry of the USSR were under GUAP (Glavnoye Upravleniye Aviatsionnoy Promyshlennosti [Main Administration of the Aviation Industry]) in the People's Commissariat of Heavy Industry; the director of GUAP was at that time P. I. Baranov, Deputy People's Commissar for S. Ordzhnoikidze. The facts of the later cruel persecutions of outstanding GIRD workers remain veiled; thus the conditions of Tsender's death in 1933 are unclear, and only recently has it come out that even Chief Designer Sergiy Korol'ov, about whom now paeans of praise are belatedly being written, was repressed and removed from his favorite work.***

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*K. Tsymbalyuk was in general a man of wide interests and a long-time aviation enthusiast. In the journal Vozdukhoplavatel' (Avigator) as early as 1909 we find articles by him (at that time he was interested in the technique of bird flight).

**L. Kolodnyy, op. cit., pp. 64.

***Ryszard Badowski: "The Chief Designer," Giuletyn Informacyjny Instytutu Losnictwa (Aviation Institute Information Bulletin), No. 12, 12 April 1966, pp. 13-14; Karel Pacner, "The Chief Designer," Radar, Casopis pro Kosmonautiku a raketovou techniju (Radar, Journal of Cosmonautics and Rocket Engineering), No. 1, Prague, 1966, pp. 4-5. (Continued on the following page)

Only gradually is the picture being sketched of the group of people who were rocketry enthusiasts in the thirties and of the difficult conditions under which they had to work. Their laboratories were located in the damp basements (cellars) of abandoned buildings. The fact is glossed over that a large part of the GIRD workers in Moscow and Leningrad were in fact amateurs, self-taught, and model-makers; the large majority of them had no engineering education, while some did not even have any connection with engineering.* A great drawback in contemporary investigations in the USSR is further that they concentrate only on studying the situations in Leningrad and Moscow and hitherto have still said nothing about other centers of the beginning of rocketry in the USSR, including those in the Ukraine.

It is very difficult to garner information on rocketry centers in the Ukraine and on related experimental institutions. It is, however, known to engineers who participated in this affair that such centers existed in the Ukraine even before 1941. Some of the better known were the research centers in the Aviation Plant imeni Baranov, as well as in the Kharkov Aviation Institute, where, by the way, Tsender regularly came with reports, as did also Volodymyr Yosypovych Rdyltovs'kyy and Colonel Gnat Stepanovych Prochko who worked in the missile field, or Prof. Mykola Romanovych Briling, who was studying new types of liquid fuel. Some of the young beginning researchers in the centers mentioned went to training schools at the well-known bases on Berezan' Island and at the Zmeyka Experimental Station of the Aerological Insitute in Slutsk, while some remained in the noted Gas Dynamics Laboratory, which was then located on Vasiliyevskiy Island (Port Grebnyy) in laboratory buildings of the Navy Department (near Leningrad), where experiments were conducted with meteorological and confidential military very-high-altitude rockets. In these centers were germinated the foci of the separate special-purpose laboratories and research institutions from which already in the post-war period came strong cadres of Ukrainian rocket experts. It must be objectively admitted that the Ukrainian laboratories found a good deal of support from such high functionaries in the People's Commissariat of Defense in Moscow as P. V. Dementiyev, A. V. Domrachev, M. V. Khrunichov, D. F. Ustinov, O. P. Kolosyanovich, and others.

The Korol'ov repressions fall in 1937-1938. In 1939-1940 he was permitted to work on the ORM-12 motor; the experimental plane with the modified ORM motor achieved a speed of 200 km per hr (the pilot was V. P. Fedoriv). Korol'ov /87 was, however, permitted complete activity only during the war when he designed the first airplane (strictly, its motors), which was tested for the first time on 15 May 1942. From 1949 Korol'ov designed high-altitude rockets for studying the ionosphere (the A-1 rocket, 85 kg in weight, reached a height of 110 km; the A-2 rocket, built in 1957 and weighing 2200 kg, reached an altitude of 212 km.).

*It must, however, be noted that a similar situation also prevailed in other countries, e.g., enthusiasts and amateurs were still predominant among the founders of the American Rocket Society in the forties. When in the early sixties it came to a union with the American Institute for Aeronautical Sciences some difficulties arose in regard to automatic (Continued on following page)

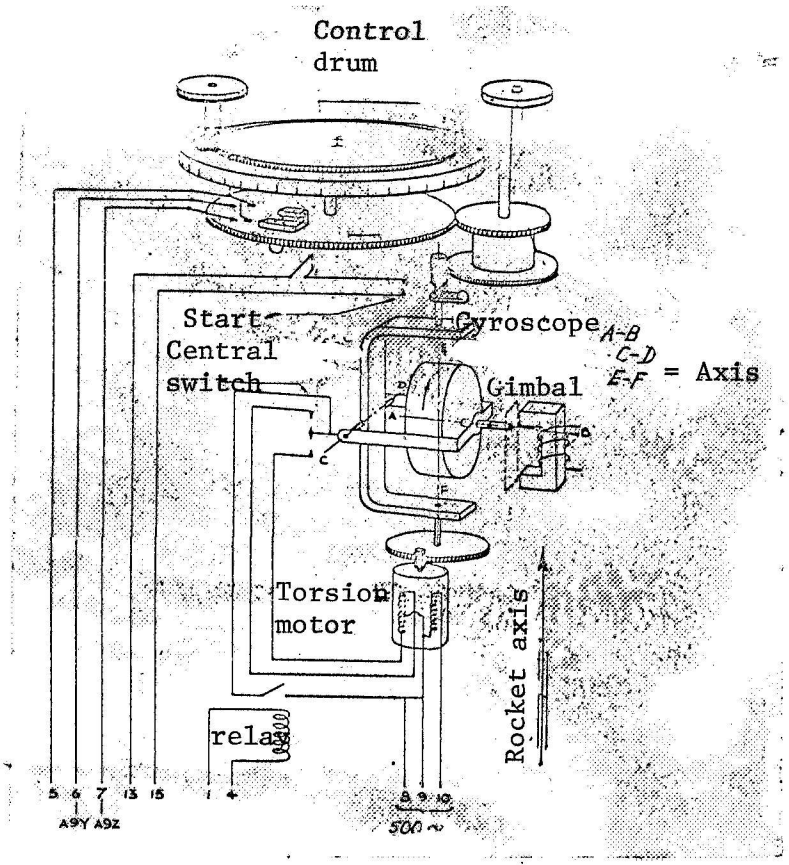

Figure 2. Diagram of Acceleration Integration Meter for Intercontinental Rockets.

A considerable role in training future rocketry cadres was played by the Scientific-Research Department of Hydrodynamics and Aviation and the Aerodynamic Laboratory of the Karkov Technological institute (as it is now called) later added to it. Georgiy Fedorovych Proskuya (chosen a member of the All-Ukrainian Academy of Sciences in 1929), who himself worked chiefly in the field of hydromechanics, rendered great service in the formation of these institutions, though such coworkers of his as Sergiy Vasyl'ovych Tarasenko 9who later became an assistant professor in the Aerodynamics Department of Voronezh University), Sergiy Volodymyrovych Gerngros, and above all Dmytro Mukolayevych Ksandrov conducted a number of fundamental experiments in hydro and aerodynamics in the Kharkov Aerodynamics Institute (which was then quartered on Kaplynovs'ka ulitsya No. 16). The mentioned scientists also assisted in setting up the Kharkov Branch of GIRD in February 1931.* In the twenties interest was already being engendered in rocketry in Kiev in the Aviation Engineering Department of the Kiev Polytechnical Institute headed by the noted scientist Viktoryn Flaviyanovych Bobrov (his works on flight aerodynamics at speeds above Mach 1 are up to the present confidential in the USSR). Interest in rocket design was also kept up by Prof. M. B. Delone, who was already elderly at that time,

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acceptance of these early enthusiasts, who did not have the proper engineering qualifications, into membership in the American Institue of Aeronautics and Astronautics. Most of them, however, became members of the prestigious AIAA.

*Vestnik Akademii nauk SSSR (Bulletin of the Academy of Sciences), No. 10, 1965, pp. 69-78; this was perhaps a branch of the Hydrodynamics Laboratory or a similar institution as a precursor of GIRD proper.

as well as by Professors V. V. Syneuts'kyy and I. Ya. Shtayerman,* who were already his assistants at that time. The results of the unique aerodynamic investigations and experiments were often discussed in the Reports of the Kiev Scientific-Technical Aviation Society (1925-1929), and some of those who gave reports at that time are today guiding scientists in the aeronautical and astronautical field, e.g., Doctor of Technical Sciences D. L. Tomashevych, Yu. S. Zhyryrts'kyy,** A. M. Gratsiyans'kyy (who won the title of Hero of the Soviet Union), K. M. Yakovchuk (the noted pilot), and others. Technical

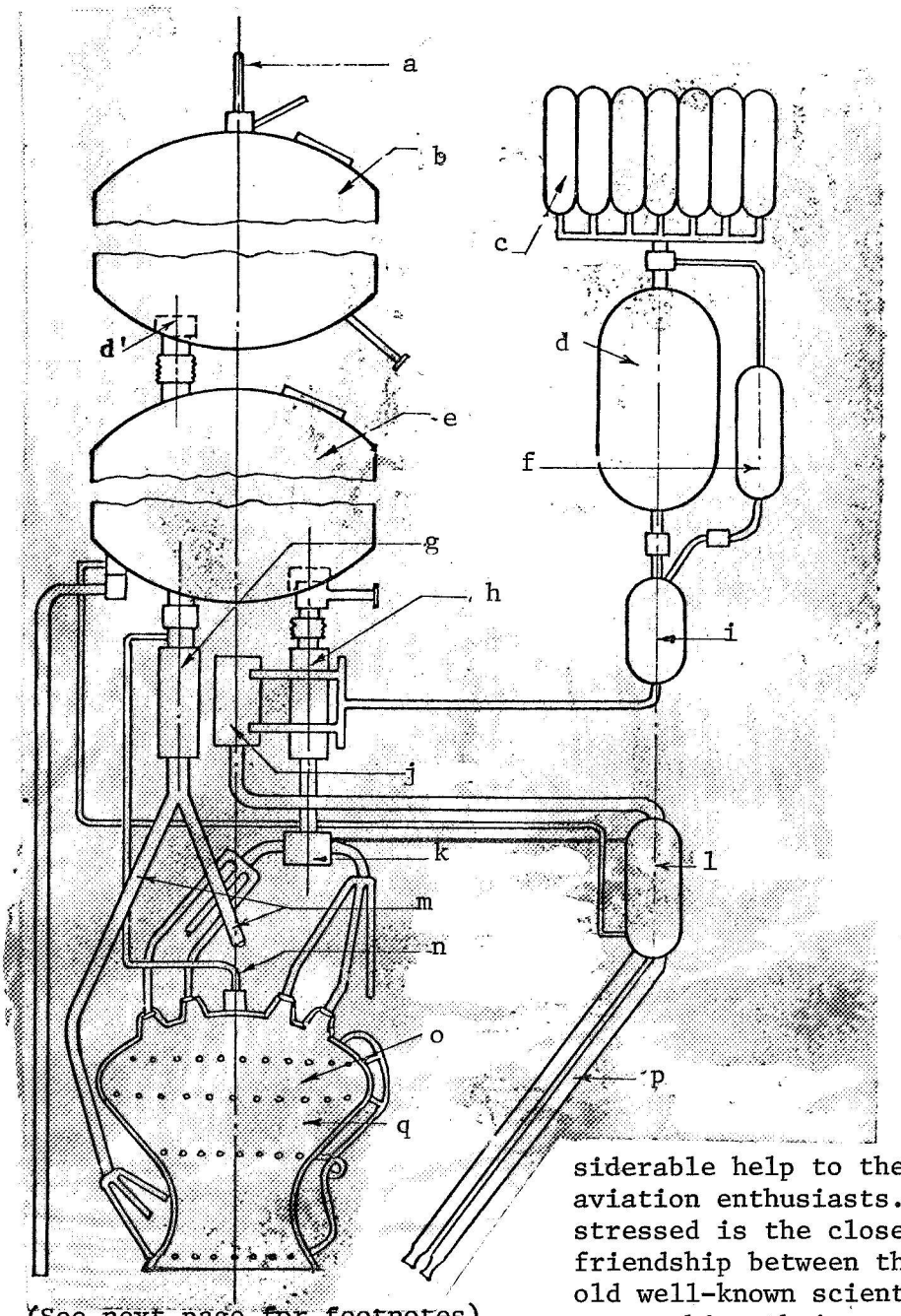

Figure 3. Diagram of Fuel Flow in Early Version of Soviet Ballistic Rocket (Modified Plan of V-2 and V-4 Engine). Key: a - Connection to rocket warhead. b - Alcohol container. c - Flasks with nitrogen under pressure. d - Hydrogen peroxide container. d - Valve. e - Liquid oxygen container. f - Container with permanganate solution. g - Alcohol pump. h - Oxygen pump. i - Vapor generator. j - Turbine. k - Distributor. l - Heat exchanger. m - Alcohol injection tubes. n - By-pass channel (to reduce driving power) o - Injector dome. p - Vapor overproduction outlet. q - Combustion chamber.

workers of one of the Kiev aircraft plants of the time ("Remzavod-6") gave considerable help to these then very young aviation enthusiasts. Especially to be stressed is the close collaboration and friendship between the generations of old well-known scientists who were then approaching their seventies and even

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eighties (Dmytro Oleksandrovych Grave, M. B. Delone) and their then very young students (D. Tomashevych, V. Savyns'kyy, K. Yakovchuk, M. Zheleznykov, A. Sorochyns'kyy, and others).

Also deserving of attention are some quasi-periodical publications in the Ukraine at that time, as Trudy Kyyivs'kogo aviatsiynogo instytuta (Proceedings of the Kiev Aviation Institute) (edited by Prof. Shtayerman) or Sborniki trudov "Laboratorii bystrokhodnykh mashin i mekhanizmov Kiyevskogo politekhnicheskogo instituta (Collections of Transactions of the Laboratory of High-Speed Machines and Mechanisms of the Kiev Polytechnical Institute) (printed in the late thirties in Ukrainian; the fate of this edition after 1955 is not known to us).

It must be remembered that for development of the theory of rocket design were assembled not only research in aerodynamics and aviation, but also, and perhaps above all, in selected areas of mechanics, materials strength (theory of elasticity), and the chemistry of combustion and explosive processes. As is known, mechanical vibrations (oscillations) are an essential phenomenon in all types of motors, and in rocket motors in particular. The groundwork for profound investigations of complex oscillations in mechanical systems was given by works of the Ukrainian Academicians M. M. Krylov and his later student M. M. Bogulyubov and their many collaborators (A. I. Lur'e, A. M. Efros, S. A. Danylevs'kyy, Sh. E. Mikeladze, and others). These investitations were conducted from the end of the twenties and the beginning of the thirties, and in 1935-1937 their results were partially published. The oscillation problems were developed in different ways; some authors used the

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*Like many of the most renowned Ukrainian scientists Prof. Illya Yakovych Shtayerman was evacuated in 1941 and spent almost all the forties in Russia, where he was coeditor of the journal Prikladnaya matematika i mekhanika (Applied Mathematics and Mechanics) (PMM); he returned to the Ukraine in the fifties and died in 1962.

**Yuriy Sergiyevych Zhyryts'kyy (1893-1966) was in fact in prewar years a great specialist in steam turbines. A graduate of the Kiev Polytechnical Institute (1915) he had already become an assistant professor in 1921 and a full professor at this Institute in 1925. A course which he wrote on steam-turbine design went through six editions and his Atlas parovykh turbin (Steam-Turbine Atlas), four editions. In the war years Prof. Zhyryts'kyy switched over to gas turbines, and here aircraft turbines in particular, and in this specialty, too, he became one of the most outstanding experts in the USSR. After the war Yu. S. Zhyryts'kyy was named professor at the Kazan Aviation Institute, while in 1963 and in 1966 (posthumously) his well-known books on gas turbines appeared in print. Prof. Zhyryts'kyy was a member of the Permanent Commission on Gas Turbines in the Academy of Sciences, USSR, editor-in-chief of the Trudy Kazan'skogo Aviyatsionnogo Instituta (Proceedings of the Kazan Aviation Institute), and in 1960-1965 also editor-in-chief of the journal Aviyatsionnaya Tekhnika (Aviation Engineering) (a series of Izvestiya Vuzov SSSR [New of Higher Educational Institutes, USSR]).

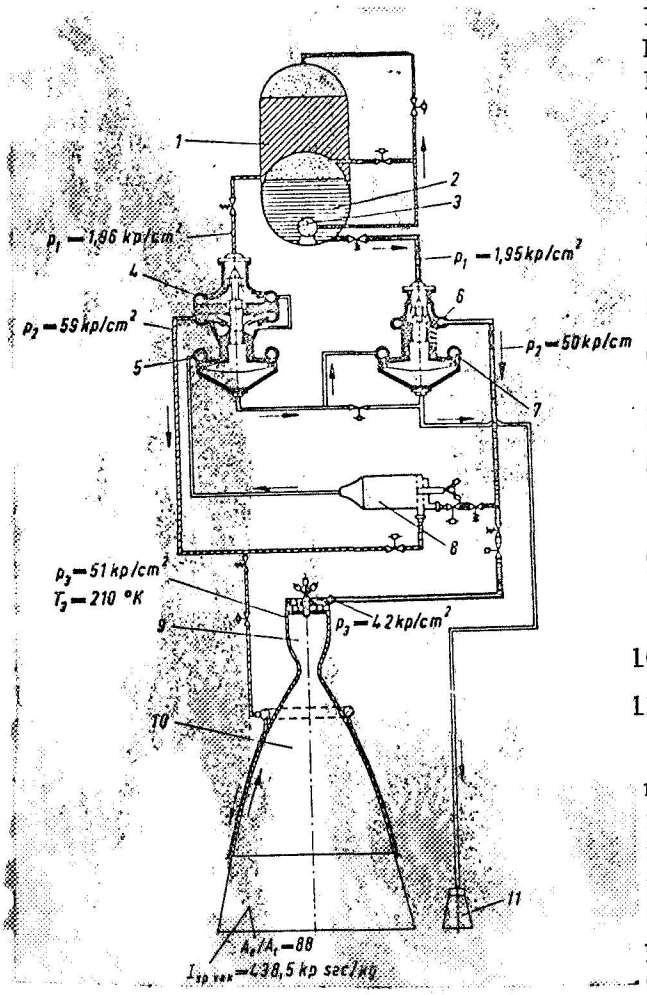

Figure 4. Diagram of Fuel Supply in a Modern Rocket (ELDO [European Launcher Development Organization] Plan (for comparison with Figure 3).

1. Liquid hydrogen container (T = 22°K)
2. Liquid oxygen container (T = 90°K)
3. High-pressure helium tank
4. Hydrogen pump (n = 50,000 [?]/min, Ne = 400 hp)
5. Hydrogen turbine (G_T = 0.32 kg/sec)
6. Oxygen pump (n = 16,700 [?]/min, Ne = 114 hp)
7. Oxygen turbine (G_T = 0.32 kg/sec)
8. Gas generator (m_G = 1 kg O_2/kgH_2; T_G = 1030°K)
9. Combustion chamber (m = 5 kg O_2/kg H_2; T = 3200°K)
10. Motor (G_S = 14.18 kg/sec)
11. Exhaust gas nozzle

method of finite differences in the transformation of differential equations, by means of whose determinants the oscillation frequency was found (A. S. Lokshyn, 1935); others employed transformation of a secular equation of n degrees of freedom into an algebraic equation which has a frequency square only in the first column (M. M. Krylov, M. M. Luzin, A. M. Danylevs'kyy, 1937). In the Ukraine were vigorously developed investigations of shock waves and their associated plastic deformations in rods (M. M. Davydenkov, M. O. Kil'chevs'kyy) and of resonance in transverse oscillations and in shells. In the Ukraine at the present time there are separate whole great schools of these investogations, and the phenomenology of theories of elasticity for thin shells and thin-walled vessels comprises the basis for the design and construction of rockets. Investigations into oscillations from the viewpoint of dynamic loss of stability with regard to damping and studies of resonance effects during starting or stopping a propulsion engine (propeller, jet, rocket, etc), as well as general research in related non-linear systems, were being conducted in many Ukrainian institutions as early as the twenties, while in the post-war years they have been consummated in the noted works of A. P. Filipov, Yu. O. Mytropol'skogo, V. S. Gontkevych, M. K. Yangel', G. S. Pysarenko, and others. /90

Academician M. Ya. Lavrent'yev, Director of the Institute of Mathematics and Mechanics of the Academy of Sciences, USSR, in 1938-1948, has become particularly well known. He worked in the geometric theory of complex variable functions and its applications to hydromechanical and aerodynamic problems, as

well as in problems of extremal methods and quasi-conformal mappings.

Studies in the field of radiolocation and radionavigation, which since the World War II period have played a predominant role in the avigation of aircraft and rockets, deserve particular attention. The origins of these investigations are to be sought in P. Oshchepkov's plans, which entered the area of radiolocation of unidentified planes for antiaircraft defense. In the secret journal Protovovozdushnaya oborona (designed only for military organizations and internal use therein) several such projects were published in 1932-1934. The Leningrad Electrical Engineering Institute (as it was called at the time), which on 19 February 1934 received definite instructions from the military authorities, elaborated several plans. The first electromagnetic reconnaissance station VNOS (Aerial Observation, Warning, and Communications) was build in July 1934 and tested on 10 and 11 July and 11 August of the same year in R-5 planes. The VNOS station wavelength was 4.7 m, antenna power was 200 watt, and aircraft location angle was 60°. In 1965 the station was improved by building into it a special IG-8 pulse tube making it possible to extend the radiolocation action to an aircraft height of about 5500 m with a recognition range of 50-60 km. A separate laboratory in the Kharkov Physico-Technical Institute worked in 1935-1936 on perfecting these radiolocation stations; Prof. D. Rozhans'kyy directed the work. Because of the 1937-1938 terror these operations were interrupted; they were partially renewed in 1939-1940; at that time the radiolocation stations RUS-1 and RUS-2 and the "Pegmatit" station were planned. Beginning with the war years research in communication by electromagnetic waves of different lengths and frequency underwent soaring development, and at present several score institutes and plants are working in this field in the Ukraine.

In the Ukraine there is also active a network of deep space communication centers to observe artificial satellites and rockets, e.g., on the Kerch Peninsula and in the mountains of the Crimea (particularly from the famous Crimean Astrophysical Laboratory); the station in the Crimea mountains is the sole station in the USSR which has been seen by a foreigner (Sir Bernard Lovel in 1963). Besides the radio-observation stations the Ukraine also has an active network of optical-observation stations for satellite tracking (Zvenygorod, Mykolayiv, Uzhgorod, Chernivtsi), which in turn ties in with a continuous network of observation stations in Eastern Europe (Cluj, Bucharest, Baja, Prague, Riga, Tartu, Poznan, Olsztyn, Wroclaw, Borowiec, Jozefoslaw, Potsdam, Bautzen, Ryazan', Vologda, Arkhangelsk).

Research by experts on combustion and new types of fuel was just as timely, but not so intensive. Confidential military factory No. 40 on the outskirts of Kazan' was particularly well-known in the twenties. Nykyfor Opanasovych Prantsuz, a native of Poltava, worked in its laboratories and together with other chemical engineers in the plant (V. S. Ryabov, M. Ye. Leont'yev, V. V. Shnegas) had already at that time developed fuels of the hydrazine type.* Similar operations were being conducted in special laboratories of the Ural Polytechnical Institute in Sverdlovsk; there in particular new types of solid explosive fuels were developed. In 1927-1928 this work was directed by the Ukrainian Mykola Yefromov, a native of Sumi. The work on

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new fuel types quickly became one of the most confidential in the USSR, and

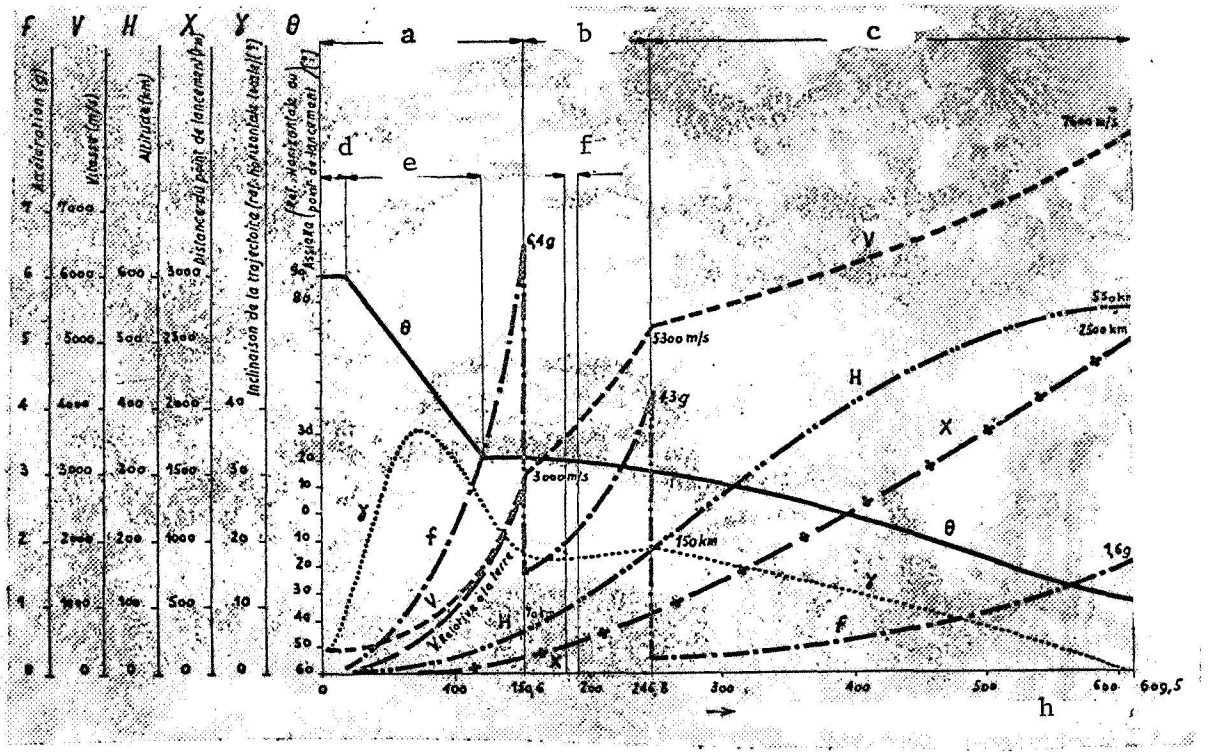

Figure 5. Trajectory Parameters of Three-Stage Rocket for Injecting a Satellite into Circular Orbit at Altitude of 555 km. Key: a - 1st stage. b - 2nd stage. c - 3rd stage. d - Vertical lift. e - Change in aspect. f - Lanyards cast off. g - Explanations: γ = trajectory inclination, V_1 = rocket speed relative to earth, V_2 = rocket speed, f = acceleration, X = distance from launch point, Ⓗ = position in orbit. h - →Time from instant of launching (sec).

almost nothing is known about investigations in the 1930-1955 period. Only in the very latest years do we note a number of names which indicate the Ukrainian

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*Kazan' has kept its significance as a research center for aviation and astronautics right up to the present. The work is coordinated by the Kazan' Physico-Technical Institute of the Academy of Sciences, USSR, in which work such noted specialists as Yu. M. Ryzhmanov, Yu. V. Yablokov, B. M. Kozyrev, L. I. Stashkov, R. O. Matevosyan, and above all the Academicians Arbuzov (father and son: Oleksandr Ermingel'dovych and Borys Oleksandrovych). Research on rocket fuels are also being continued in the Ukrainian Polytechnical Institute imeni S. M. Kirov.

Already in 1939-1941 the best-known experimental laboratories for explosives and new types of aviation fuel were located (Continued on next page).

cadres are well represented in this field. Research centers exist in Kiev (military laboratories, e.g., in the Higher Engineering-Aviation Military School of the VPS of the USSR, Institute of Thermophysical Engineering of the Academy of Sciences, Ukrainian SSR), in the Dnieper region (Pridneprov'ye) (laboratories in military factories), and in Odessa and environs. Of the best-known names we may mention D. I. Polishchuk, V. G. Karpenko, V. O. Fedosiyev, G. N. Lyubshyk, V. A. Khrystych, and V. I. Fedoriv. A very solid group of Ukrainian experimenters works in the all-Union central laboratories, particularly in various organizations of the Institute of Physical Chemistry of the Academy of Sciences, USSR, whose work is directed by the noted scientist Ya. B. Zel'dovych and his coworkers; among the Ukrainian researchers in this group we may count E. Stuponchenko, L. Kozachenko, M. I. Shevlyuk, K. V. Yushko, V. Ya. Basevych, S. M. Kogarko, T. A. Ponys'ko, A. S. Sokolyk, L. F. Chekerda, and others. With these investigaters are continually collaborating scientists from the Institute of Thermophysical Engineering of the Academy of Sciences of the Ukrainian SSR -- P. I. Lavrov, Yu. G. Klymenko, V. G. Vyshnyak, and other. We have here dwelt in more detail only on research in /92
a single field, i.e., combustion processes of new types of rocket fuel. It would be illogical to list other Ukrainian specialists in rocketry since we know only of very few of them, while in reality there are many thousands of them. All-Union reputations belong, for example, to the spaceship designers M. K. Yangel', O. I. Ivashchenko, I. A. Boguslavs'kyy, T. I. Isachenko, V. V. Andriyevs'kyy, M. Nazarchuk, Yu. P. Gupalo, F. L. Chornous'ko, V. F. Dyachenko, I. P. Soprunenko, V. F. STepanchuk, S. A. Yarko, O. O. Goroshko, and B. O. Cherkasov; many outstanding aviation specialists are today working on cosmonautical problems -- N. S. Lysets'kyy, V. A. Myronenko, S. Yu. Skrypnychenko, T. M. Bashta, Yu. I. Kyrylenko, and R. I. Khrapko; the contingent of scientists who have distinguished themselves in designing parts for new jet engines is particularly strong-- V. Ye. Doroshenko, S. M. Il'yashenko, M. M. Bondaryuk, V. B. Neaperenko, A. I. Borysenko, S. P. Aleshchenko, A. V. Shtoda, S. M. Shlyakhtenko, A. I. Petrusevych, and G. S. Skubachevs'kyy. The collective of astronautical scientists must also be reckoned to contain specialists in radio communications and radio navigation, geophysicists (ionosphere and cosmic ray studies), astronomers, biologists, pysicists in the solid state field (semiconductors), in plasma, and in lasers, as well as further specialists in directly military disciplines.

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in the Dneprodzerzhinsk Nitrogen Fertilizer and the Donetsk (then Stalingrad) Bomb Plants.

It should be mentioned here that the Zel'dovych and Arbuzov schools of studying combustion processes such other schools are operating in this field as those, for example, of M. M. Semenov, M. M. Emanuel', E. Librovych, and L. Vulis.

Many Ukrainian rocket and astronautical scientists are working outside the borders of the Ukraine. There is, however, nothing surprising in this; quite as in the United States where rocketry centers are located for the most part in isolated and desert regions of Arizona, New Mexico, Florida, and Southern California, so in the USSR such centers are situated far to the rear in the Asiatic part of the USSR, and obviously there is place there for the pertinent specialists. The Ukraine is a too thickly populated country, and moreover with climatic conditions unsuited to spaceship launching experiments, for such bases to be constructed in it as Vandenberg in the United States, Woomera in Australia, or Baykonur, Tyura-Tan, and Sari Shagan in the USSR.

But, disregarding such objective reasons and the fact that some research and development centers in the USSR astronautical program are located on Ukrainian territory (usually in subterranean installations*), we have evidence that the principal installations (i.e., not merely cosmodromes) are chiefly situated on Russian territory or in separate points in the Asiatic regions which remain under the special control of Moscow, e.g., in the environs of Karaganda or in the Baikal region (Pribaykal'ye). The situation is approximately the same as in the aviation construction sector -- the aircraft built in the Ukraine, as well as the aircraft engines, fall into the category either of the small and weak, e.g., the An-24 or even the An-12, or of the extremely large and rarely used (very small series production, e.g., the An-22). In both cases the flying speed of these airplanes is low by modern standards. The modern high-speed passenger planes of the Il-62 type and supersonic planes of the Tu-144 type are, however, all built chiefly in Russian plants (we are not discussing the production of military aircraft). Ivchenko engines are also much less than Kuznetsov or Mykulin engines.** It is to the point that a number of new factories were constructed in the Ukraine only when it became known in Moscow that the Americans had managed to get accurate maps of the location of military industry in the Central Russian and Ural regions and when the Kremlin comprehended that such concentration of this industry was extremely dangerous from a strategical viewpoint. The conflict with China and the reconciliation with Western Europe are also in a certain measure conducive to enlargement of the aviation and rocket industry in the western and

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*"Why the Russians are Convinced They Will Win the Space Race," Realites (Realities), No. 244, May 1966, pp. 76-77. The most important of the factories outside the Ukraine are according to the 1965 situation those in Chkalov, Magnitogorsk, Alma-Ata, Semipalatinsk, and Krasnodar.

**There is no opportunity here to make an accurate analysis of the distribution of the most important projects in the Soviet rocket program. While rocket construction is concentrated for the most part in regions near the Urals a number of auxiliary projects are being executed in other republics of the USSR, particularly in the Ukraine. By way of example we mention the biological research which is being done in the Ukraine by special large centers in the Vinnytsa Medical Institute and the Medical Faculty of the Dniepropetrovsk University. The Clinical (Continues on the next page)

southwestern regions of the USSR, hence particularly in the Ukraine. Whatever this situation may be, it must be realized that it is still early to speak of the part played by Ukrainian scientists and engineers in the aeronautic and astronautic program of the USSR. For known reasons most of the pertinent data are strictly confidential. Still more confidential are data on the developmental centers associated with this program. We believe, however, that in good time we will learn much more about the part of the Ukraine in the contest for mastery of space.

Physiology Laboratory of the Bogomolets' Institute in Kiev is particularly famous; a number of its workers (M. Tsyrotkin, K. Markov, V. Pyngvych, V. Yuzov, and others) together with the Moscow scientists V. Parin and O. Isakov coordinate all research in space medicine in the USSR; see "Kiev Gets an Assignment," in the book by Rainer M. Wallisfurth, Russlands Weg zum Mond (Russia's Way to the Moon), Econ Verlag (Econ Publishing House), 1964, pp. 250-256.

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